# Integrated manufacturing planning in agri-food supply chains – Towards end-to-end integration in a Norwegian meat company

Torbjörn H. Netland[1], Dr. Erlend Alfnes[2], Ingvill Heskestad[3]

[1] SINTEF Technology and Society
Dep. of Operations Management
N-7465 Trondheim
Tel 0047 98245169
Torbjorn.Netland@sintef.no

[2] Norwegian University of Science and Technology
Department of Production and Quality Engineering
N-7465 Trondheim
Erlend.Alfnes@ntnu.no

[3] Nortura BA
Logistics Development Group
Tungaveien 26
N-7484 Trondheim
Ingvill.Heskestad@nortura.no

**Abstract**
Agri-food supply chains struggle to balance consumer demand with supply from farmers and production capacities. In order to achieve a true lean agri-food supply chain, and thereby enhance the value and margin of products, there is a need for end-to-end integration across the chain. This paper presents the results from a Norwegian research project, where an action research methodology has been applied in the largest meat company in Norway. To create the needed end-to-end integration, it is proposed that agri-food production companies should use integrated manufacturing planning teams, which are tightly coordinated with customers and supplying farmers.

**Category:** Case study
**Keywords:** Supply chain management, integrated manufacturing planning, agri-food supply chains

**Background**

The food industry can indisputable be held out as the most important industry in the world. However, agri-food supply chains often experience a more complex task in balancing supply and demand than many other industries do; in pork production, for example, hogs should be slaughtered as they reach the ideal slaughtering weight, and as the hog is slaughtered the whole carcass should be exploited within a limited amount of time. Consumers, on the other hand, want ribs to the barbecue season and roasted leg to Christmas. This imbalance between supply and demand in agri-food supply chains must be minimised with proper integrated manufacturing planning.

The agri-food industry has large improvement potentials regarding supply chain management and operation management issues (e.g. Alfnes et al, 2000; Van der Vorst et al, 2005; Fritz and Hausen, 2006; Taylor, 2006a; Zokaei and Simons, 2006). Taylor and Fearne (2006) highlight the poor demand management in agri-food companies. There is typically no attempt to link the start of agricultural production with the expected consumer demand at the time the product will be ready for harvest or slaughtering (Taylor, 2006a). Retailers and processing companies do not provide farmers with forecasts of consumer demand that helps farmers take volume decisions. None of the agri-food supply chains in Taylor's (*ibid*) study have some kind of cooperative demand forecast for the whole chain, quite in contrast; every firm did its own forecast in isolation from each other.

Interestingly, Taylor (2006a) found that the consumer demand is generally the least variable element in the demand pattern, and furthermore that the bullwhip effect (Forrester, 1958) together with the unpredictable supply from farmers and batch-size policies in the production companies creates inefficiencies in the chain. Fritz and Hausen (2006) found that inefficient order processing in reception and order placement processes are evident, and that most food-supply chain networks have large improvement potentials in information integration. In addition, there is a strong tendency in agri-food supply chains to base relationships on a trading mentality where all actors aim to maximise their own profit (Taylor, 2006b).

All these examples indicate that agri-food supply chains are less mature than other industries when it comes to supply chain management and end-to-end integration. The purpose of this paper is to report on findings from a Norwegian research project aiming at creating more efficient agri-food supply chains. More specific; a meat company's possibilities of creating a lean agri-food supply chain is investigated. Lean agri-food supply chains balance the demand from customers with the supply from farmers and the resource capacities in production, in a way that optimise total supply chain performance.

**Methodology**

The results in this study stem from an ongoing research project, which is funded by the Norwegian Research Council and is led by the dominant Norwegian meat company. In addition the largest wholesaler of fruits and vegetables in Norway has a partner role in the three-year research project named InnovaRFID.

An action research methodology (e.g. Gummesson, 1988; Arbnor and Bjerke, 1997; Greenwood and Levin, 1998) has been applied; where the researchers have been involved in and facilitated improvement processes. In action research projects, the researchers are both participants as well as observers, which give detailed insight into processes, procedures and data in the case companies. The conclusions were drawn in a joint team of both researchers and practitioners.

**Theory**

The concept of supply chain management was first introduced in 1982 by Oliver and Webber, and since then there has been a continuous and expanding development of the concept. According to Hsiao et al (2006), supply chain management 'aims at managing the supply chain network as a single entity and to plan and control the total goods and information flows from suppliers to end users effectively and efficiently'. Both the definition and the characteristics of supply chains place great emphasis on integration, and implicate a need for a total-network planning and control of logistics throughout the network. Information sharing and operational planning are keys for successful integration.

With its roots in retail, Collaborative Planning Forecasting and Replenishment (CPFR) has grown as a joint effort to balance supply and demand across supply chains and create end-to-end integration. Traditionally CPFR was a web-based attempt to replace existing EDI-solutions (Fliedner, 2003). Larsen et al (2003, pg. 532) explain CPFR as "the collaborations where two or more parties in the supply chain jointly plan a number of promotional activities and work out synchronised forecast, on the basis of which the production and replenishment processes are determined". CPFR has been proven successful from a retail chain perspective (Danese, 2006) with examples such as Wal-Mart, Kmart and Procter & Gamble; however there remain challenges for production companies to implement CPFR without the leadership of the retailers (Holmström et al, 2002).

The lean agri-food supply chain is discussed among others by Taylor (2005, 2006 a, b) and Zokaei and Simons (2006). Summing up the main points of Taylor (2006 a, b) from the point of view of a processor; the main characteristics of a true lean agri-food supply chain are:

- A value chain management team led by a senior level representative from each of the companies along the chain is established
- A single long-term forecast is used by all actors in the supply chain
- Streamlined information systems in the supply chain with reliable and consistent data flow between chain partners on consumer sales, ordering patterns and inventory levels
- Promotional activities across the chain are strategically used to level demand variation
- Consumer demand is 'micro managed', where daily order patterns in the weekly trading cycle are input to timing of production upwards in the supply chain
- Agricultural production is linked to consumer demand by developing a pull system

In order to make a first move towards linking farm production and consumer demand, Taylor (2006a) addresses the need for a CPFR team balancing the supply and demand across the whole supply chain from farmer to retailer. This true lean approach described by Taylor is an ideal and maybe too optimistic idea: The supermarket chains are only gaining in power, and will probably continue to dictate the market in the future as well. So, the meat processors should not wait for the retail chains to take initiative, but rather start building the lean supply chain downwards to the supermarkets. To do this, a vertical integrated meat company is an advantage.

In agri-food supply chains there has been clear trend that supply chain management is exercised through mergers and vertical integration. In fact, most literature on agri-food supply chains emphasise vertical integration as the key for future competitiveness (e.g. Den Ouden et al, 1996; Lawrence et al, 2001; Bhuyan, 2005; ECON, 2005; Van der Vorst et al, 2005; Bijman et al, 2006). Vertical integration has been on top of the agenda in the agri-food processing industry since the 1980s, when the first steps where taken in the pork industry (Schultze et al, 2006). Best practice examples, such as the world-leading Danish pork

production (Hobbs et al, 1998; Windhorst, 2004), are used as proofs of well working vertical integrated agri-food companies. Vertical integration is hold out as a prerequisite to create real end-to-end integration in agri-food supply chains

**The case company**

With its ca 8000 employees and more than 40 production facilities the case company is the dominant producer of red and white meat in Norway. The company is a cooperative owned by its 30.000 suppliers. The production processes span from slaughtering to refinement. In 2006, the company sold more than 100.000 ton red meat in its national market which compromises ca 50 % of the total Norwegian end-market. The market share in slaughtering is ca 70 %. Because the case company is a vertical integrated company, controlling the whole chain from the transport of animals to the abattoirs, to the expedition of goods to the wholesalers and retailers, this case study contributes to a broader insight of the effects and challenges of vertical integration.

The case company is described as the most complex supply chain network in Norway, where ten characteristics are of the utmost importance for the case company:

1. Divergent goods flow with three main raw materials (pork, sheep, cattle) and more than 2000 end products
2. The whole animal must be exploited when first slaughtered
3. Geographical spread farms with a low degree of specialisation (opposite to the Danish meat industry structure), combined with the requirement of maximum time of transport of animals to the abattoir
4. Strong requirements to transparency and track and trace
5. Limited and varying durability of products combined with large differences in processing time
6. Large season variations both for supply and demand
7. Low degree of automation and much expensive handwork
8. The role as the national meat market regulator (a sort of governmental responsibility to secure supply and influence demand in the meat market in Norway)
9. Requirement by law to receive the animals when the farmer request it
10. Imbalance in supply chain power and fierce competition among powerful retailers lead to late requests for sale campaigns and late pricing of products

The case company's supply chain can be decomposed into breeding in production farms, slaughtering at the abattoir, partition and refinement in processing plants, bringing the meat to the market in retail chains and HoReCea (hotels, restaurants and catering), and finally meat consumption by people (Figure 1).

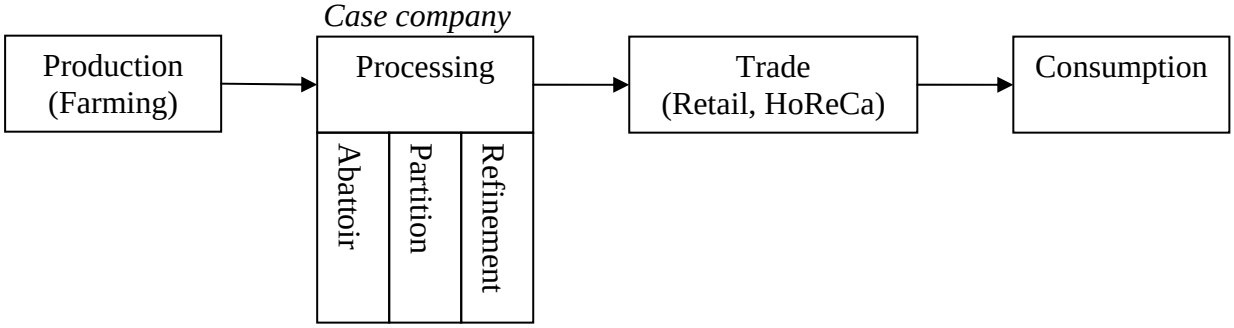


**Figure 1 Overview of the meat supply chain in the case study**

Netland et al (2007) found that the case company has large improvement possibilities in regard to a lack of information integration in the supply chain and a need for better production planning routines. The existing strategic priorities in the case company listed in Table 1, underline the present focus of improvements in operations management and supply chain management issues.

**Table 1 The strategic priorities in the case company (2007) underline the importance of Operations Management and Supply Chain Management issues**

| *Strategic priority* | *Field* |
|---|---|
| - Increased centralisation and specialisation | OM/SCM |
| - Automation of production | OM/SCM |
| - Increased capacity exploitation | OM/SCM |
| - Reduction of inventory | OM/SCM |
| - Increased used of wholesaler distribution (cross-docking) | OM/SCM |
| - Increased focus on brand image | S |
| - Increased sales in niche markets | S |
| - Increased food safety and tracking | CSR |
| - Increased environmental consciousness regarding CO2 | CSR |

OM/SCM= Operations-/Supply Chain Mngm, S= Sales, CSR= Corp. Social Responsibility

**Interface inefficiencies in the case supply chain**

The case company was thoroughly analysed in order to find ways to secure predictability and stability in the production processes from slaughtering to refinement. In particular the roles and interfaces between the different manufacturing planning departments and the sales departments where mapped together with the relationships to farmers, production units and retail chains. Figure 2 gives an overview of the case supply chain and outlines the interfaces which were mapped.

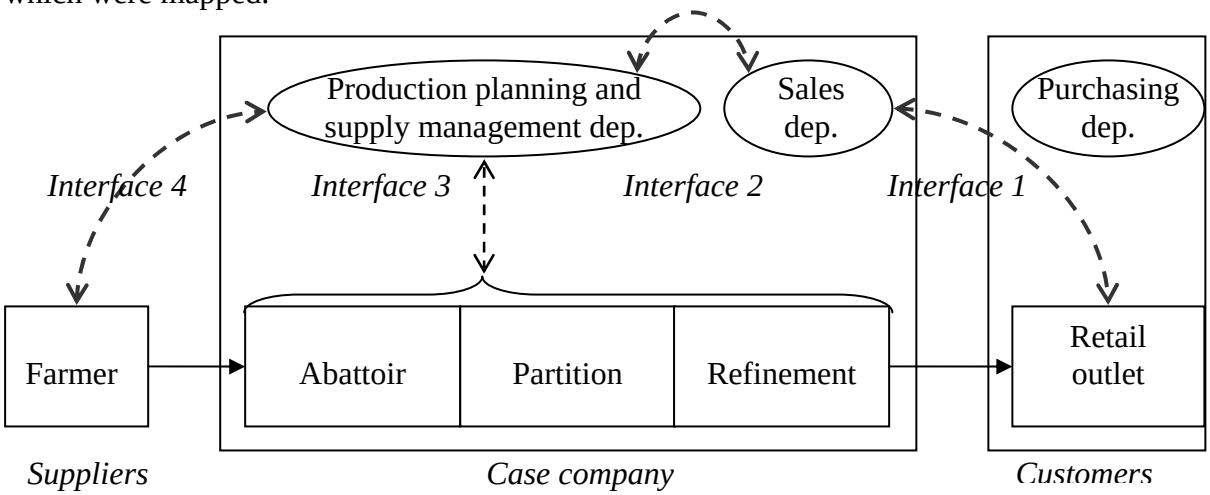


**Figure 2 Actors and analysed interfaces in the case company**

Through several interviews and workshops with key persons in the case company, inefficiencies in the interfaces between actors were mapped.

*I1:* Key persons from the sales department stress the uneven power balance towards the retailer chain. As in the UK (e.g. Taylor, 2006b) the Norwegian meat industry is to a large

degree dictated by the supermarket groups. In Norway four retail chains control 99 % of the market share. There is a fierce competition between the chains which lead to late requests (or demands) for campaigns and activities, because none of the chains want the information to leak to competitors. Today, the chains request campaigns only five weeks prior to the campaign dates. The case company prefer an eight weeks horizon, because this would create more predictability and thus both stability and flexibility in production. In addition to late requests, the chains often wait even longer to agree on a price for the meat.

*I2:* From time to time, the sales department sell without consideration of production capacities. There are IT-systems available for the sales department that contain information about capacities, which are in use to some degree. However these systems suffer under irregular and complicated manual updating. In addition, the use of such systems is to a high degree dependent on individuals; some planners and sellers use the systems more than others. Thus, there is a need for better and simpler interface systems that help balancing the products at demand in the sales department with the production capacity upstream in the supply chain.

*I3:* The interface between production planners and production are characterised by two main inefficiencies; First, the highly person dependent planning systems gives a wide variety of routines and a lack of standards both among the production planners and the manufacturing execution. The case company has started a detailed process modelling at one of the ca 40 production sites, which at a long run has the potential to become a corporate wide quality handbook where best practice process standards are described. Second, there is a lack of clear roles when it comes to the production plans' richness in detail. The factory managers express a low degree of control and a high degree of responsibility, which leads to frustration. There is a need for creating clarity in roles and responsibilities.

*I4:* The largest improvement potentials are found in the interface between the supply management and the farmers. The case company does not order the animals as they are needed, but are passive recipients of request from farmers on date for slaughtering of animals. Thus, there is a complete lack of supply information, and the supply horizon is as short as 1-2 weeks for pork (while pork must be received within two weeks after the farmer's request, cattle has a flexibility buffer of up to seven weeks). This happens despite that all needed information on Norwegian livestock is in principle available in different national databases. Today only 50 % of pork farmers request slaughtering through the modern web-portal. For cattle and sheep the number is even lower. The case company do not use supply contracts with its 30.000 suppliers (and owners). Despite the fact that the case company's Nordic counterparts, Swedish Meats and Danish Crown, stress supply contracts as important for stabile and predictable demand, supply contracts are still not very common in Norway.

Table 2 sums up the discussed interface inefficiencies between the actors in the supply chain.

**Table 2 Interface inefficiencies in the meat supply chain**

| |
|---|
| *I1 Interface between customer's purchasing department and the Sales department* |
| - Power imbalance leads to short demand horizon and late pricing for meat producers<br>- Tactical notification of sales campaigns due to competition between retail chains |
| *I2 Interface between the Sales department and Production planning* |
| - Sales sell without consideration of production capacity<br>- Production planning does not rely on sales prognoses made by Sales |
| *I3 Interface between Production planning and Production* |
| - Highly person dependent planning systems gives a wide variety of routines and a |

| |
|---|
| lack of standards<br>- Lack of clear roles and responsibilities |
| *I4 Interface between Supply management and Farmers* |
| - Lack of supply information and very short supply horizons, even though information on animal birth, type and total livestock is available<br>- Lack of contracts |

**Actions towards a more efficient meat supply chain**

Evidently the case company struggles with the balance between unpredictable and limited supply and the sales departments desire to sell more than possible of what the customer wants and less of the by-products. Thus, our findings support among others Fritz and Hausen (2006) and Taylor (2006a) that agri-food supply chains have a need for end-to-end integration. Three improvement suggestions are put forward by the joint team of researchers and practitioners, which reduce the inefficiencies mapped in the case company's supply chain interfaces, and move the case company towards the true-lean supply chain discussed by Taylor (2006a, b):

1. Balance supply and demand across the chain from farmer to retailer through long-term integrated manufacturing planning teams with longer planning horizons
2. Balance consumer demand and production capacities by integrating the sales department and production planning teams
3. Balance consumer demand and supply from farmers by utilising available information on the supplier's livestock and introducing supply contracts with the largest suppliers

The case company choose to implement joint planning teams for long-term production planning. The long-term planning teams will be responsible for one kind of animal (pork, sheep, and cattle) across all production sites. In addition to the operational planning, the team will coordinate supply of animals from farmers. Capacity constraints and market demand will be exchanged with the sales department. Thus, "integrated manufacturing planning" means activities for planning long-term manufacturing budgets at all stages in the supply chain that balances demand, supply and resource capacities across the chain. In this way, long-term integrated manufacturing planning is in accordance with the very goal of supply chain management as defined by Hsiao et al (2006). The establishment of the long-term planning teams is the first step towards a chain-wide CPFR-team (Taylor, 2006a).

Longer planning horizons is a prerequisite for end-to-end planning in agri-food supply chains. A longer planning horizon creates a better top-down approach for the whole supply chain, where the balance between consumption and supply is cleared out as early as possible and all actors are given the best conditions for optimised processes. This means for instance that the meat producer should have better possibilities to control, recommend or even turn down sales campaigns at the retail chains. In addition, the meat company can suggest, or even order, the birth date of animals from farmers. It also gives new possibilities to optimise the resource capacities and staff plans for the next year.

According to Taylor (2006b), sales personnel and production planners should work in cooperative teams to handle both sales and production planning in true lean supply chains. However, from a practitioner's view, with a total of 8000 geographical spread employees and a whole nation's varying supply and demand, such teams are difficult to handle. Thus, a communication platform between the sales department and the planning teams is suggested. A database will contain real-time data on supply capacity and production capacity illustrated in the user interface by intuitive sell/not-sell signals. All data should be new data and captured as automatically as possible. Punching should be minimised and replaced with accept/not accept-

choices. Drill-down functionality from product groups to single products will be available. In addition to giving the production planning team better prognoses earlier, it is a goal that the planning team can advice the sales department about what they can sell and what they *should* sell based on transparency of anticipated supply and production capacities.

It is a goal to make breeding of animals more demand driven than it is today through more end-to-end integration (Taylor and Fearne, 2006). The suggested long-term planning team is a means to this challenging task. The long-term manufacturing plan is suggested to be a rolling plan, differentiated on kind of animals. For example pork and lamb production will have a rolling plan updated every second week with a horizon of the next 52 weeks. Because breeding a hog to slaughtering weight of about 75 kg takes ca eight months (32 weeks), the rolling 52-week horizon gives a 20 week time window to plan and order production start date for hogs. For sheep and cattle the plan should have even longer horizons. The challenge is to predict precise and right prognoses on a longer horizon. However, in addition to the fact that the annual consumption of meat and meat products do not vary substantially from year to year, the case company has traditionally very good tools and experiences with sales forecasting.

Available information about the supply capacity livestock should be exploited; In Norway, births of all animals are registered in national databases, which the case company has access to. Even though these data give a quite good forecast of the size and time of supply to the abattoirs, they are not utilised for planning purposes in the case company today. With the introduction of a new long-term planning team, a better utilisation of existing and available data is demanded. It is also suggested to use contracts with the largest suppliers, in line with theory on vertical integration (e.g. Windhorst, 2004; ECON, 2005).

Figure 3 illustrates the main actions suggested in the case company for moving towards a more efficient (lean) supply chain as discussed by Taylor (2005, 2006 a, b).

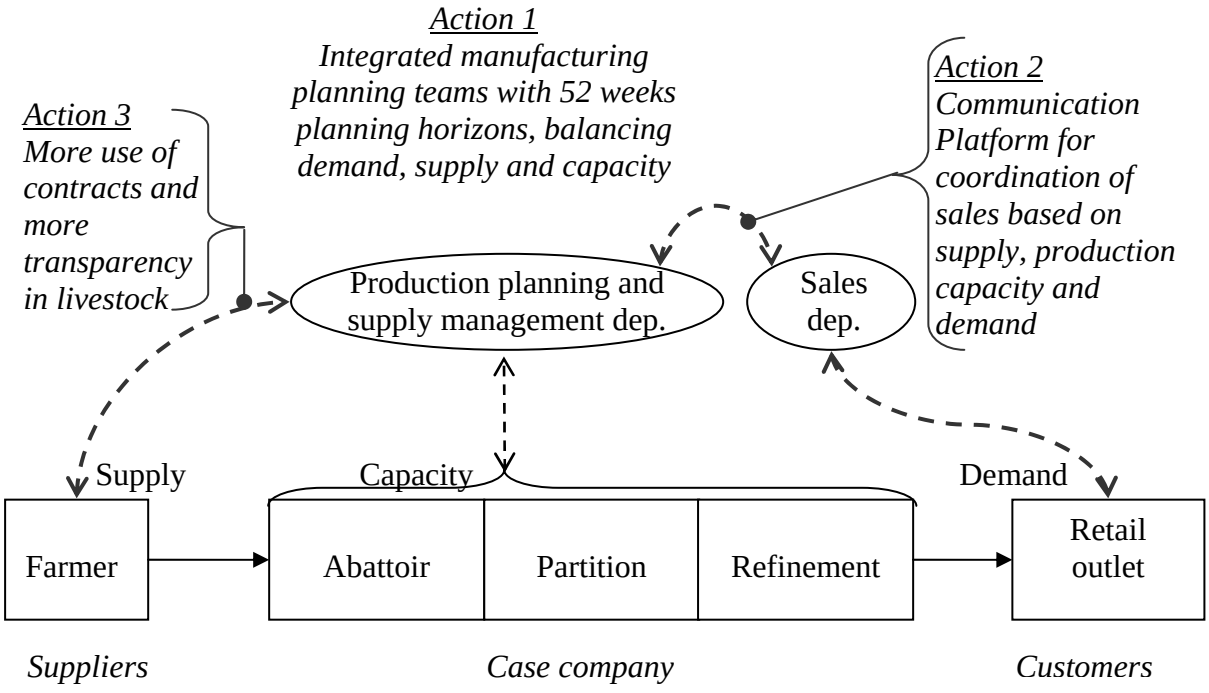


**Figure 3 Towards a more efficient (lean) agri-food supply chain in the case company**

The integrated manufacturing planning presented here leads to five main effects;

1. Due to better planning; considerably more value can be realised for the meat producer, because more products can be sold as fresh, (the majority of meat producers use value-reducing freezing to prevent expired shelf lives)
2. Due to correct available-to-promise data; less products are sold that cannot be delivered, and hence the service level to customers increases
3. Due to smoothing of the bullwhip effect; large inventory reductions are realised through-out the value chain
4. Due to levelled supply; production processes are given more stabile and predictable conditions
5. Because the meat processor will pay extra for the delivery security and agreed flexibility in ordering and call-off processes; contract farmers are given higher prices for the animals

**Conclusions**

It is of importance for agri-food supply chains to coordinate their flow of materials so that demand is met with the right products at the right time. Partly explained by the structure in retail markets and still strong national protectionism in food markets, agri-food supply chains lay behind other industries (such as the automobile industry) when it comes to leanness in their operations. In this paper we argue that the true lean agri-food supply chain discussed by Taylor (2006a, b) is yet not to be realised. However, the integrated manufacturing planning presented here, moves agri-food supply chains from a traditional hierarchy of disintegrated functional planned business units *towards* an integrated process flow supply chain. Integrated manufacturing planning is an effort to create a reasonable tact time through the supply chain so that actual demand is met with a predictable and stabile material flow.

In order to develop the true lean agri-food supply chain more research is called for. In particular there is a need for more empirical research identifying best practices for end-to-end integration in agri-food supply chains.

**References**

Alfnes, E.; Røstad, C.C.; Strandhagen, J.O. 2000, *Flexibility requirements in the food industry and how to meet them*, In proceedings of the 4th international conference on chain management in agribusiness and the food industry, 25-26 May 2000, Wageningen

Arbnor, I.; Bjerke, B. 1997, *Methodology for creating business knowledge*, Sage Publications, London

Bhuyan, S. 2005, *An empirical evaluation of factors determining vertical integration in U.S. food manufacturing industries*, Agribusiness, vol. 21, iss. 3, pp. 429-445

Bijman, J.; Omta, S.W.F.; Wijnands J.H.M; Wubben, E.M.F. 2006, *Management and organization in international agri-food chains and networks*, in *International agri-food chains and networks*, edt. by Bijman, J.; Omta, S.W.F.; Wijnands J.H.M; Wubben, E.M.F. 2006, Wageningen Academic Publishers

Danese, P. 2006, *Collaboration forms, information and communication technologies, and coordination mechanisms in CPFR*, Int. J. of Prod. Resa., vol. 44, no. 16, pp 3207-3226

Den Ouden, M.; Dijkhuizen, A.A.; Huirne, R.B.M; Zuurbier, P.J.P 1996, *Vertical cooperation in agricultural production-marketing chains, with special reference to product differentiation in pork*, Agribusiness, vol. 12, pp. 277-290

ECON 2006, *Norsk kjøttindustri etter 2008 – er vi forberedt på ny WTO-avtale?*, Rapport 2006-070

Fliedner, G. 2003, *CPFR: an emerging supply chain tool*, Ind. Mngm. + Data Syst., vol. 103, no.1/2 pg.14

Forrester, J. 1958, *Industrial dynamics – a major break-through for decision makers,* Harvard Business Review, July-August

Fritz, M.; Hausen, T. 2006, *Tailored improvements of supply chain processes in agri-food networks*, in *International agri-food chains and networks*, edt. by Bijman, J.; Omta, S.W.F.; Wijnands J.H.M; Wubben, E.M.F. 2006, Wageningen Academic Publishers

Greenwood, D.J.; Levin, M. 1998, *Introduction to Action Research*, Sage Publications, London

Gummesson, E. 1988, *Qualitative Methods in Management research*, Chartwell-Bratt Ltd., Studentlitteratur, Lund, Printed in Sweden

Hobbs, J.E; Kerr W.A.; Klein, K.K 1998, *Creating international competitiveness through supply chain management: Danish pork*, Supply Chain Management, vol. 3, iss. 2, pg. 68

Holmström, J.; Främling, K.; Kaipa, R.; Saranen, J. 2002, *Collaborative planning and replenishment: new solutions needed for mass collaboration,* Supply Chain Mngm., vol. 7, no 3/4, pg. 136

Hsiao, H. I.; van der Vorst, J. G.; Omta, S.W.F 2006, *Logistics outsourcing in food supply chain networks: Theory and practices*, in *International agri-food chains and networks*, edt. by Bijman, J.; Omta, S.W.F.; Wijnands J.H.M; Wubben, E.M.F. 2006, Wageningen Academic Publishers

Larsen, T.S.; Thernøe, C.; Andresen, C. 2003, *Supply chain collaboration: thehoretical perspective and empirical evidenc*e, Int. J. Phys. Distrib. Logist. Mngm., vol. 33, pp. 392-549

Lawrence J.D.; Schroeder, T.C.; Hayenga, M.L 2001, *Evolving producer-packer-customer linkages in beef and pork industries,* Rev. Agric. Econ., vol. 23, pp. 370-385

Netland, T.; Alfnes, E; Fauske, H. 2007, *How mature is your supply chain? - A supply chain maturity assessment test*; In Proceedings of the 14th International EurOMA Conference Managing Operations in an Expanding Europe, Ankara, Turkey, 17-20 June 2007

Schultze, B.; Spiller, A.; Theuvsen, L. 2006, *Is more vertical integration the future of food supply chains? Empirical evidence and theoretical considerations from german pork production,* in *International agri-food chains and networks,* edt. by Bijman, J.; Omta, S.W.F.; Wijnands J.H.M; Wubben, E.M.F. 2006, Wageningen Academic Publishers,, pp. 49-63

Taylor, D.H. 2005, *Value chain analysis: an approach to supply chain improvement in agri-food chains,* Int. J. of Physical Distribution & Logistics Mngm, vol. 35, no. 10, pp. 744-61

Taylor, D.H. 2006a, *Demand management in agri-food supply chains – An analysis of the characteristics and problems and a framework for improvement*, Int. J. of Logistics Mngm, vol. 17, no. 2, pp. 163-186

Taylor, D.H. 2006b, Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector

Taylor, D.H.; Fearne, A. 2006, *Towards a framework for improvement in the management of demand in agri-food supply chains*, Supply Chain Management: An Int. J., vol. 11, iss. 5, pp. 379-384

Van der Vorst, J.G.A.J; Beulens, A.J.M; van Beek, P. 2005, *Innovations in logistics and ICT in food supply chain networks,* In Jongen, WMF; Meulenberg, MT.G 2005, *Innovations in Agri-food Systems*, Wageningen, Wageningen Academic Publishers, pp. 245-292

Windhorst, H-W 2004, *Qualitätssicherung in der Lebensmittelkette – wo liegen die Herausforderungen?* In Dachverband Agrarforschung ed., *Lebensmittelqualität und Qualitätssicherungssytseme*, VerlagsUnionAgrar, pp. 21-33

Zokaei, A.K; Simons, D.W 2006, *Value chain analysis in consumer focus improvement – A case study of the UK red meat industry*, Int. J. of Logistics Mngm, vol. 17, iss. 2, pp. 141-162